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BOOK REVIEWS

Black Holes Wormholes and Time Machines

by Jim Al-Khalili

Institute of Physics Publishing : Bristol-London-Philadelphia-Paris-St Petersburg (1999)

256 pages, illustrated, price £ 9.99/$16.50 (paper back)

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Jim Al-Khalili's Black Holes, Wormholes and Time Machines is an entertaining account of physics at the end of a tumultuous century of developments. It deals with issues at the forefront of research today in a lighthearted, engaging style meant for readers with little or no background in these subjects. The chapter on the Universe, for instance, begins with the quote from a student : The Universe may be closed, but it opens again after lunch. The ambitious purpose, in the words of the author, is "edutainment"

The book is broadly divided into three parts : Space, Time and Time Machines. The first part, Space, has four chapters, ands runs to about 110 pages. The second one, Time, has approximately 84 pages divided into three chapters. The third part, three chapters nearly 60 pages long, is about Time Machine.

The twentieth century began with the far reaching ideas of Bohr that gave birth to quantum mechanics. These investigations led us to the submicroscopic world of structures and their interactions. Two new basic forces, namely the Weak and the Strong, were added to the two others, the Gravity and the Electromagnetic, that were known earlier. Later, in the second half of the century, came theories and ideas that began to unify these forces.

From the beginning, the role of the Gravity stood out. Its course was charted by the General Theory of Relativity that was at odds with ideas of quantum mechanics. Attempts at putting these two theories together, into what is called quantum gravity, ran into deep mathematical problems. Quantum Gravity turned out to be an inconsistent theoretical model

For the good part of the century most physicists did not care. The General Theory of Relativity, as it is, is forbidding enough. On top of that the solutions of the theory, right from the beginning, had the Alice-in-Wonderland sort of make-believe quality. Early in the game, came the black hole solutions of Karl Schwarzchild. These spacelike point singularities have infinite densities. None of the physical laws hold at these points. Time stops at the black holes. While a minority of the mathematical physicists found the theory to be a goldmine to be dug further, for most others, and for the physicists-at-large, the theory of gravity demanded too much from their imagination. It did not help either that Einstein himself devoted a good bit of his time trying to hide these singularities. In the process, came the Einstein-Rosen bridges that are supposed to connect our universe with other parallel ones! Later came the other solutions of spinning black holes with timelike ring (instead of point) singularities. Here, the way the space and the time warps is different. Since the singularity is timelike it is the edge of space. In a sense, this Kerr singularity gives us the window to what lies beyond our universe.

For the majority in the community, all of these were as fascinating as they were demanding, many secretly wished these, and other even more bizarre solutions, would somehow go away!

But that was not to be. Physicists trying to unify the weak, the electromagnetic and the strong found, to their surprise, that the unification, if it is to occur, takes place at scales where the gravity could not be ignored. Over the years the astrophysicists found evidence that the black holes are more than mathematical curiosities. They could exist! In short the General theory simply could not be ignored. The difficulty was that Bohr's quantum mechanics and Einstein's gravity were still reluctant to work together.

The last fifteen years have brought new approaches to these issues. The superstring models and their later-day variants have managed to bridge the gulf between the gravity and quantum mechanics. The latest theories, therefore, tell us as much about the world of the submicoscopic as they tell us about the universe around us.

For many of us in the physics community, the fast-paced last-fifteen-years have left us in a state of bewilderment. The fond hope that the gravity could perhaps be ignored lies in shambles. In addition to the heavy ideas of strings and membranes, the whole subject of Astrophysics now has to

be studied alongside. That certainly brings us to Jim Al-Khalili.

This book, despite the lighthearted presentation, deals with issues that are serious. The questions it raises are the ones haunting the researchers today. The fact that most of the questions remain unanswered tells us about the state of our knowledge in these areas now. In its 260 pages, Al-Khalili takes us on a fascinating journey through the universe, through the black and the white holes, through tubes that connect different parts of our universe and to other universes. It tells us a lot about how the universe was created, what existed before the universe and about the ideas of time-travel. Modern day Astrophysics in concert with the General Relativity and Jim Ali-Khalili take us to the edge of the universe and to the borderline of the absurd. Science fiction pales in comparison.

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Synchrotron Radiation and Free Electron Lasers

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CERN Geneva, 1998
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Synchrotron radiation source has become one of the most valuable and useful scientific tools for fundamental and applied research in different disciplines of science. Enormous progress in design of sources and the range of applications have generated the urgent need for CERN schools for updating the knowledge in this field. The book under review is an outgrowth of tenth CERN Accelerator School on Synchrotron radiation and Free-electron lasers held in 1996. The purpose of these schools is mainly to collect, preserve and disseminate the latest knowledge on accelerator and related systems in different accelerator laboratories around the world.

The book has several chapters on basic theory of synchrotron radiation, electron dynamics in storage rings, beam insertion devices, beam current and radiation brightness limits and then these themes are developed with more detailed discussions on other intricacies like wigglers and undulators, beam life and quality *etc.*

A Hoffmann in his first lecture, has introduced a qualitative treatment on synchrotron radiation stating from potentials and fields of a moving charge, radiation from a charge moving on a circular orbit and undulators related to beam diagnostics have lucidly been discussed. L Z Rivkin in second lecture, has dwelled on the basic ideas behind the working of electron storage rings with an emphasis to how the radiation process shapes the equilibrium properties of electron beam. Introduction to wigglers and undulator magnets—the so called 'insertion devices' and the relativistic motion through them and the coherent undulator radiation are then discussed by K Wille. Current and brightness limits are potentially of crucial concern for synchrotron light sources as they can impose a limit on the usefulness of the source. V P Suller has demonstrated how the electromagnetic field associated with beam currents can significantly interact with structures surrounding the beam and can limit the current. The factors that limit the brightness of radiation have also been explained. A Ropert in his lecture has emphasized the need for storage ring lattices specially designed to maximize high brilliance synchrotron radiation and achieve full potential from insertion devices. The basic features of the design and performance of insertion devices, radiation characteristics and magnetic design have been discussed nicely by R P Walker. He ended up with special requirements of undulators used for free-electron lasers *viz.* development of small-period device, incorporate additional focussing into the magnetic structure *etc.* The physics of the mechanisms of instabilities and beam intensity limitations in circular accelerators have been discussed elegantly by S Myers using few particle model, matrix technique involving eigenvalues and Sacherer's model technique. Maintaining the brightness of synchrotron radiation source is of fundamental importance C J Bocchetta has given an overview on the concept of brightness and factors affecting it like transverse beam stability, aperture limitations, beam gas scattering, quantum lifetime, intra-beam Coulomb scattering, beam instabilities and ion trapping. L Farvacque has discussed briefly different aspects of beam stability, ways of quantifying beam stability sources of instabilities and the remedial measures to be taken. Synchrotron radiation is an extremely important tool for diagnostics in electron/proton rings using special magnets A Hoffman has dealt with the subject nicely to understand the three key types of measurements made with synchrotron radiation. In the last chapter, R J Bakker has discussed elaborately the design and operational aspects of storage ring free-electron laser. The proceeding would have been a more complete one had the contributions on Scientific applications, Industrial and medical applications and Linac FEL were there as those are very much required from the users' point of view.

The proceedings of the course would be very useful for those working with synchrotron radiation and free electron laser which now a day an important light source for many types of research.

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